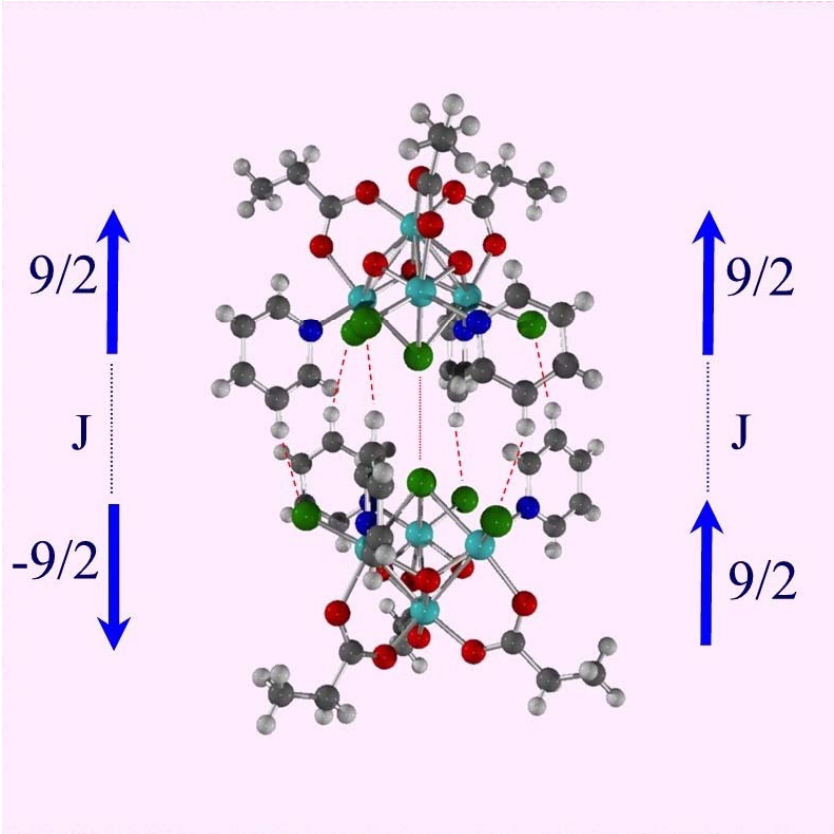
Quantum Effects in Single Molecule Magnets - I
Andrew Kent, New York University, DMR-0103290

This project focuses on the synthesis and study of molecules that contain a small number of metal atoms, such as 12 manganese ions or 8 iron ions, that lock their individual magnetic moments together to form a larger and coherent "nanomagnet". The resulting moment of the molecule, unlike that of a single ion, is potentially large enough to detect and to use in an electronic device to process or store information. Further, crystalline arrays of such nanomagnets have been synthesized in which each element of the array is a molecule. The molecules in this array are thought to be inherently "alike", just like all sugar molecules are alike. This route to arrays of nanomagnets may be contrasted with the alternative method that use slow and complex electron beam lithographic techniques to create arrays of nanomagnetic metals, such as iron and cobalt. Until recently, the sameness of single molecular magnets, like sugar molecules, was taken for granted. In addition, magnetic forces between molecules in arrays were assumed to be small.

In recent work by this NIRT team--Christou, Dalal, Hendrickson, Hill and Kent--it has been shown that the molecules are not always magnetically identical and also that nearby molecules can interact strongly with one another. Magnetic differences and intermolecular interactions are detected as subtle features of the electron magnetic resonance spectrum and magnetic properties of single crystals. These effects, previously undetected, will need to be understood at a fundamental level if these molecules are to be used as device elements. Their study requires a team effort, involving chemists and physicists and state-of-the-art instrumentation at New York University, University of California at San Diego, University of Florida and Florida State University and the National High Magnetic Field Laboratory.



The structure of the $[Mn_4O_3Cl_4(O_2CEt)_3(py)_3]_2$ dimer, denoted $[Mn_4]_2$. Each Mn_4 has a spin of 9/2 and applies a large internal “exchange field” to its pair in the dimer via the hydrogen bonds (dashed lines in the figure). Red, oxygen; cyan, manganese; green, chlorine; blue, nitrogen; gray, hydrogen; black, carbon.

Quantum Effects in Single Molecule Magnets - II
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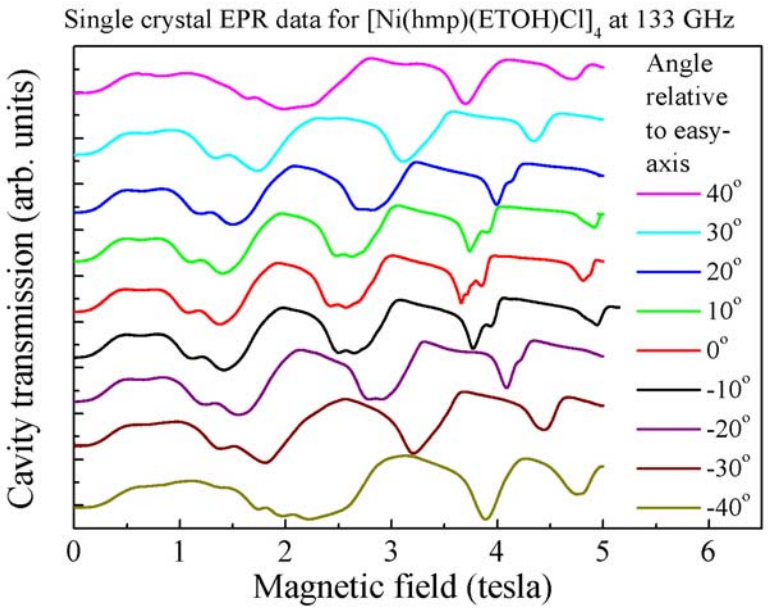
Brief summary of outreach activities:

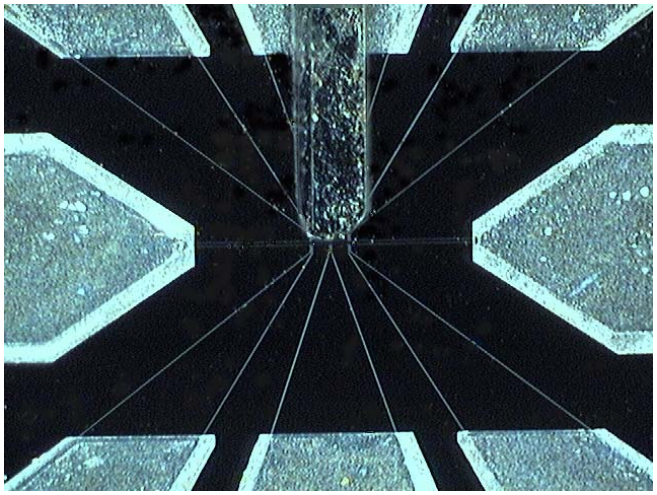
•Graduate, undergraduate students, and postdoctoral fellows have received interdisciplinary research training as a direct consequence of this project.
•Two symposia have been organized for the Fall 2002 that will highlight this project.
•A tutorial on SMMs is planned at the Fall MRS meeting.
•REU students are being hosted this summer.

Educational

5 undergraduates,
12 grad students,
3 post-docs.



Mn_{12} crystal on a micro-Hall magnetometer



Magnetic hysteresis Mn_{12} 0.6 K